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(54) Wellbore fluids

(57) A wellbore fluid is disclosed which comprises a liquid dispersion of a particulate mixed metal carbonate which has a generally platey crystal form. The mixed metal carbonate is preferably a mixed alkaline earth metal carbonate, and most preferably a natural or synthetic huntite.

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WELLBORE FLUIDS

This invention relates to wellbore fluids suitable for use in the oil and gas exploration and production industries and embraces fluids used for drilling, completion, cementing, workover or packing of wellbores, and includes so called "spacer fluids" and "spotting fluids" whose functions are, respectively, to separate dissimilar fluids during pumping operations, and to spot or treat certain intervals of the wellbore. The term "wellbore fluid" also embraces so-called "fracturing fluids" which are pumped at a pressure sufficient to fracture the rock forming the producing reservoir.

During well construction, there are many occasions when it is necessary to pump wellbore fluids which are viscosified in order to, for example, remove debris such as cuttings from a well, or which are gelled sufficiently to suspend quantities of powdered dense minerals such as barytes.

It is also frequently important that the slurries forming the wellbore fluids do not leak-off or filter into permeable formations at a high rate. For instance during drilling, high filtration rate fluids may produce a thick filter cake leading to sticking of the drill string. Equally the invasion of large quantities of filtrate may damage the permeability of reservoir rocks causing reduced hydrocarbon production. If cement slurries filter too readily, premature solidification of the cement may occur during the pumping operation. Fracturing operations are less efficient if the fracturing fluid "leaks-off" into porous rock, losing the pressure required to fracture further.

Whilst many soluble polymers have been developed to provide viscosity and filtration control, it is frequently desirable to combine these with, or use

alone, finely divided minerals to enhance or achieve the above properties.

According to a first aspect of the invention, there is provided a wellbore fluid comprising a liquid dispersion of a particulate mixed metal carbonate which has a generally platey crystal form.

Where the wellbore fluid is two phase, for example an emulsion wellbore fluid having oily and a water phases, the particulate carbonate may be dispersed or mixed in either or both of the phases.

Preferred mixed metal carbonates are the mixed alkaline earth metal carbonates, and presently the most preferred of these is huntite.

Huntite is a carbonate of calcium and magnesium of the general formula $CaMg_3(CO_3)_4$. It occurs in nature in the USA and Greece as compact masses of very small crystals of the order of 1μm and the crystals are generally platey in nature. The chalk-like material as mined is readily milled, and the mineral easily disperses to discrete crystals on shearing in water.

The particulate mixed metal carbonate, such as huntite, should preferably have an aspect ratio of at least 5 and will typically have a particle size distribution such that a high proportion, such as 90% or more, of the particles have an equivalent spherical diameter (esd) in the range of from 0.1 - 5μm.

The invention is not restricted to mixed metal carbonates, such as huntite, obtained from natural deposits. Synthetic huntite or other synthetic mixed metal carbonates obtained by precipitation from aqueous solutions may be a potential alternative source.

In the wellbore fluid of the invention, the mineral particles may be dispersed or mixed in any liquid phase, suitable for a wellbore fluids such as, for example, fresh water, sea water, brines of water soluble salts, oily liquids such as petroleum oils and

derivatives, esters, ethers, mono alphaolefins, polyalphaolefins, acetals, and emulsions.

It has surprisingly been found that mixed metal carbonates having a generally platey crystal character, such as huntite (natural or synthetic) will confer the advantageous properties of increased viscosity and gelation, and of reduced filtration rate, when mixed into the liquid phase.

Unlike bentonite which will only develop viscosity and filtration control in relatively fresh water, platey mixed metal carbonates such as huntite are effective by direct mixing into brines such as solutions of the halides of the alkali metal or alkaline earth metal groups, formates of the alkali metal group, and potassium carbonate. Particulary advantageous results have been obtained using brines of formates of the alkali metal group, such as potassium formate; these give good results when the mixed metal carbonate is huntite.

Unlike attapulgite and asbestos, whose fibrous nature presents a health hazard by dust inhalation, huntite is of low risk, and its filtration control effect is superior.

Another significant advantage of platey mixed metal carbonates such as huntite over the clay minerals is that they may readily be dissolved in acids, allowing simple removal by acidisation of residual huntite solids which may temporarily plug channels such as perforations in an oil or gas producing formation.

Other additives which may be contained in the wellbore fluid of the invention include, but are not limited to: cement, water soluble polymers such as xanthan gum, hydroxyethylcellulose and other cellulose derivatives, guar gum and derivatives such as hydroxypropyl guar, pregelatinised starch and derivatives such as carboxymethylstarch; synthetic

polymers such as polyacrylamides, polyacrylates, and copolymers of sulphonated ethylenically unsaturated monomers with other vinyl monomers. Emulsifiers and wetting agents may be added when required. Density increasing agents such as powdered barytes, hematite or calcium carbonate may be incorporated. The wellbore fluid may contain other additives known to those skilled in the art.

The dose of the mixed metal carbonate, such as huntite, in the wellbore fluid is preferably at least about 3.5 lbs per barrel (10 kg/m^3). The preferred upper limit for the amount of huntite in the wellbore fluid is about 140 lbs per barrel (400 kg/m^3).

Optionally, for applications in wellbore fluids comprising an oily continuous liquid phase, the mixed metal carbonate, such as huntite, may be treated prior to use with an agent rendering the surface of the huntite particles at least partially hydrophobic. The hydrophobising agent may be an agent having one or more polar portions (such as an alkyl chain or chains, the or each of which has from, for example, 10 to 30 carbon atoms) and a suitable polar portion, and may, for example, be selected from the group including, but not being limited to:

fatty acids such as stearic or palmitic acid and their soaps;

phosphate esters of alcohols or alcohol ethoxylates possessing a sufficiently large alkyl chain to provide the hydrophobising effect, and their salts; and

alkyl sulphonates or alkylaryl sulphonates and their salts.

The pretreatment may, for instance, consist of the addition of sufficient of the hydrophobising agent to a slurry of the mixed metal carbonate, followed by filtration, drying and milling. Alternatively, the

filtration and subsequent steps may be omitted, the slurry of hydrophobised huntite being added directly to the wellbore fluid. This latter process may be performed at the well site.

According to a second aspect of the invention, there is provided a method of well construction, well remediation or stimulation wherein a wellbore fluid according to the first aspect of this invention is employed.

After the operation is completed, the well may be directly prepared for production. Alternatively an acidic solution such as hydrochloric acid may be introduced to the well whereupon residual mineral solids, such as the filter cake deposited during the method, are dissolved by the acid causing the opening of flow channels in the reservoir interval, and allowing increased production of hydrocarbons, or increased injection of fluids in the case of an injection well.

The invention will now be illustrated by reference to the following examples. In these examples, the wellbore fluid properties were tested in accordance with API (American petroleum Institute) RP 13B-2 1990.

The following abbreviations are used:

PV	The plastic viscosity of a drilling fluid (centipoise). Generally low PV is advantageous.
AV	The apparent viscosity of a drilling fluid (centipoise).
YP	The yield point ($lbs/100ft^2$) of the fluid and is a measure of the non Newtonian viscous characteristics.
6 rpm & 3 rpm	Dial readings on the Fann Viscometer which indicate the viscosity at low shear rates. Higher 6 rpm, and 3 rpm values indicate greater thixotropy which

is generally advantageous.

Gels — A measure of the gelling and suspending characteristics of the fluid ($lbs/100ft^2$), determined using the Fann viscometer.

API FL — API room temperature fluid loss. A measure of the ease of filtering a drilling fluid through a filter paper at 100psi differential pressure. Results in millilitres of filtrate. Low filtrate volumes are advantageous.

EXAMPLE 1

An aqueous potassium formate (75% w/w) brine exhibited a specific gravity of 1.57. Its viscosity and filtration properties were measured.

To 522 grams of the potassium formate solution was added 45 grams of powdered huntite. The suspension was mixed for ten minutes using a Silverson high shear mixer. The resulting viscous slurry exhibited a specific gravity of 1.62. Its viscosity was measured prior to dynamic heat ageing (BHR) of the fluid in a rolling pressurised cell for sixteen hours at 142°C (288°F), whereupon (AHR), its viscosity and filtration properties were determined. The results obtained are displayed in Table 1 which appears at the end of this description. The results show the ready development of very advantageous viscous properties by the simple mixing of huntite into a dense potassium formate brine. Good rheological properties are maintained after exposure to a high temperature (142°C). Surprisingly, the huntite confers a eight-hundred-fold reduction in filtration rate.

EXAMPLE 2

A sodium chloride brine of specific gravity 1.14 was viscosified with IDHEC* hydroxyethylcellulose according to the following formulation which produces 350 ml of fluid:

Water	324.5 g
Sodium Chloride	73.8 g
IDHEC	1.0 g

A similar formulation was mixed to include powdered huntite according to the following formulation (also to 350 ml).

Water	307.8 gram
Sodium Chloride	70.0 g
IDHEC	1.0 g
Huntite	45.0 g

The rheological and filtration properties of both fluids were measured and are displayed in Table 2 which appears at the end of this description. The results show that huntite imparts a very advantageous increase in yield point and, in particular, in the low shear rate viscosity and gels of the fluid. This particularly improves the suspending ability of the fluid and its ability to carry cuttings, suspended larger particles, or debris in a wellbore pumping operation.

The huntite has conferred a very advantageous reduction in filtration rate by a factor of one thousand two hundred.

EXAMPLE 3

The filter cake from the filtration test in Example 2 was placed in a beaker and covered with 15 percent hydrochloric acid. Rapid and complete dissolution of the cake occurred. This illustrates the advantage that residual wellbore fluid of the present

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* Mark of Schlumberger

invention, and its filter cakes may readily be removed from a wellbore by conventional acid pumping operations.

Table 1

	PV	YP	6 rpm	3 rpm	Gels	API FL
75% Potassium Formate Brine	2	0	0	0	0/0	200 ml in 5 sec
Brine + 45 g Huntite BHR	18	64	18	18	8/10	-
Brine + 45 g Huntite AHR	40	80	19	16	10/12	90 ml in 30 min

Table 2

	PV	YP	6 rpm	3 rpm	Gels	API FL
Brine + IDHEC	11	10	1	1	1/1	180 ml in 5 sec
Brine + IDHEC + Huntite	30	85	35	30	23/25	18 ml in 30 min

CLAIMS:

1. A wellbore fluid comprising a liquid dispersion of a particulate mixed metal carbonate which has a generally platey crystal form.

2. A wellbore fluid according to claim 1, wherein the mixed metal carbonate is a mixed alkaline earth metal carbonate.

3. A wellbore fluid according to claim 1 or 2, wherein the mixed metal carbonate is natural or synthetic huntite.

4. A wellbore fluid according to any one or more of the preceding claims comprising an oily continuous liquid phase, wherein the mixed metal carbonate has been treated prior to use with an agent rendering the surface of the mineral particles at least partially hydrophobic.

5. A method of well construction, well remediation or stimulation wherein a wellbore fluid as claimed in any one of the preceding claims is employed.

6. A method according to claim 5, wherein an acidic solution is introduced into the wellbore to dissolve residual mineral solids deposited during the method.

7. A wellbore fluid substantially as hereinbefore described with reference to the accompanying examples.